FESTINA LENTE

SYNOPSIS OF LECTURES

IN

ANATOMY AND PHYSIOLOGY

ARRANGED FOR THE BOSTON NORMAL SCHOOL OF GYMNASTICS

BY

EMMA L. CALL, M.D.

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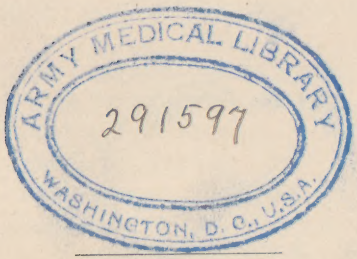

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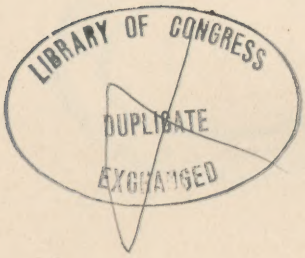

SECTION I.— SKELETON.

SKELETON, solid framework of body.

Uses:—

To sustain weight.

To form points of leverage for muscles.

To protect vital organs.

In full grown animals composed of bone.

In higher animals covered with skin, muscles, fat, etc.

BONE:—

Structure of: { $\frac{1}{3}$ animal substance (gelatine). $\frac{2}{3}$ mineral substance (of which 50% is calcium phosphate, 11 % calcium carbonate).

Mineral substance may be dissolved out by HCl. Shape remains perfect, but soft and flexible.

Animal substance removed by burning. Bone becomes light and brittle.

Formation of: { compact / cancellated } difference in density.

Teeth, very hard form of bone. Hardness due to enamel.

Shape, long, short, flat, irregular.

Definitions employed in reference to bone:—

Articulation, union of two bones.

Articular surface, parts of bone between which union takes place.

Process, projection from main part of a bone.

Tuberosity, a rough, broad prominence.

Tubercle, a small, rough prominence.

Spine, a sharp, slender projection.

Fossa, a shallow depression.

Foramen, a passage into or through a bone.

General rule in examining a bone: a smooth eminence or depression marks an articular surface; a rough surface marks attachment of muscles, ligaments, or tendons.

Difference in appearance between fresh and dried bone.

PERIOSTEUM, fibrous membrane containing cells and blood-vessels which covers outside of fresh bone except at articular surfaces.

Bone derives nourishment through the blood-vessels.

Cells help to form new bone.

If destroyed to any extent, bone dies.

MARROW, soft, fatty substance (red or yellow) which fills spaces in cancellous tissue, and in shaft of long bones.

Red chiefly in young bones (many blood-vessels).

Yellow has more fat cells.

Contributes to growth of bone from within.

SKELETON of a vertebrate distinguished by the vertebral or spinal column, a flexible column of bones extending lengthwise through the body, whose office is: —

1st. To support, directly or indirectly, all the other parts of skeleton.

2d. To protect spinal cord.

VERTEBRAL COLUMN, possessed by mammals, birds, reptiles, and fishes.

In man, extends from base of skull to tip of coccyx.

Skull is modification of vertebral column to receive the brain.

Composed of twenty-four true or separate vertebræ, and nine false or united vertebræ.

True vertebræ, characteristics of: —

1st. *Body*, solid anterior portion.

2d. Two *pedicles* projecting backward from body.

3d. Two *laminæ* which curve toward each other and unite in median line behind.

4th. Seven *processes* for attachment of muscles, ligaments, and bones. These include two *transverse* projecting laterally from some part of pedicle, four *articular* from union of pedicles and laminæ, one *spinous* projecting from union of laminæ.

5th. Spinal foramen, space enclosed by body, pedicles, and laminæ.

True vertebræ divided into: —

CERVICAL (1st to 7th vertebræ inclusive).

DORSAL (8th to 19th vertebræ inclusive).

LUMBAR (20th to 24th vertebræ inclusive).

Cervical vertebræ. Flexibility needed more than strength. Distinguishing mark in mammals and birds, a foramen in transverse process for vertebral artery.

Other characteristics: body small, light, broad transversely, inferior border prolonged to lap over next vertebra. Laminæ long and thin. Spinal foramen large. Spinous process bifid for muscles. Articular surfaces look obliquely upward and downward.

Dorsal vertebræ. Each attached to a rib. Many muscles attached. Mobility less than in other regions. Distinguished by facet on body of vertebra for articulating with head of a rib.

In most cases each rib is attached between two vertebræ,

the articular surface being partly on each. In animals, ribs are often prolongations of the transverse processes of vertebræ. Nearly all dorsal vertebræ have a second facet, on transverse process, for articulating with tuberosity of rib.

Further characteristics of dorsal vertebræ: body, diameter greatest antero-posteriorly, larger than cervical, smaller than lumbar. Laminæ broad and thick. Spinal foramen small, nearly circular. Spinous processes long and oblique. Articular surfaces look backward and forward.

Lumbar vertebræ. Chief characteristic, its massiveness. Strength needed to bear the weight of body. Distinguished from other vertebræ by exclusion, having neither foramen in transverse process nor facet for rib.

Other characteristics: body large and heavy, pedicles and laminæ short, broad, and thick. Spinal foramen smaller than cervical region, larger than dorsal. Spinous process short, broad, thick, nearly horizontal. Articular surfaces look inward and outward.

PECULIAR VERTEBRÆ:—

First cervical: *Atlas*, supports head. No body nor spinous process. In front only ring of bone. Pedicles present ear-shaped fossæ for condyles of occiput. Spinal foramen very large to accommodate enlargement of cord, and also to prevent pressure. Anterior portion encroached upon by tubercles for transverse ligaments, which hold axis in place.

Second cervical: *Axis*, pivot on which head turns. Distinguished by a tooth-like (odontoid) process, projecting upward from the body and taking the place of body of Atlas. On the front of odontoid process is a smooth facet, which lies against ring of Atlas. Process held in place by transverse ligament. Tip rough for check ligament, which binds it to occiput. Spinous process large and strong, for muscles that rotate head.

Seventh cervical: *Vertebra prominens*, very long spinous process.

Vertebræ fastened together directly by articular processes; indirectly by intervertebral disks of cartilage interposed between bodies. These disks increase mobility, and serve as cushions to lessen the jar. Articular processes interlock and form very firm union. Space between the body and interlocking processes called intervertebral foramïna.

FALSE VERTEBRÆ nine. Five unite to make sacrum, four the coccyx.

Sacrum, pyramidal bone, concave anteriorly, convex posteriorly, consisting of five vertebræ welded together.

Anterior surface smooth; shows lines of division between bodies of vertebræ.

Foramina correspond to intervertebral foramina.

Lateral portion represents transverse processes.

Posterior surface rough, rudimentary spinous processes.

Articular surface laterally ear-shaped for articulation with hip bones. Foramina posteriorly, continuation of those anteriorly.

Spinal canal continued through bone.

Base articulates with last lumbar vertebra, apex with coccyx.

Coccyx, four rudimentary vertebræ, tapering off nearly to a point. No spinal canal, and only very imperfect bodies and processes.

SECTION II.— THORAX.

Thorax, or chest, formed by union of dorsal vertebræ, ribs, and sternum.

STERNUM, or breast-bone,— narrow, flat bone, sword-shaped,— consists of three pieces: —

Superior portion, *manubrium*, or handle.

Middle portion, *gladiolus*, or blade.

Inferior portion, *siphoid*, or *ensiform* appendage.

To manubrium are attached clavicle, first rib, part of second rib. To gladiolus, part of second rib, and all of third, fourth, fifth, sixth, part of seventh. To end of appendage, lower part of seventh. All ribs are attached to sternum indirectly by intercostal cartilage.

RIBS, twelve pairs: —

Seven pairs *true*, attached to sternum by intercostal cartilages.

Five pairs *false*, attached to cartilages of other ribs.

Three pairs *floating*, no attachment anteriorly.

RIBS as a whole vary: —

In direction, obliquity increases from first to ninth, decreases to twelfth.

In length, increases first to seventh, decreases seventh to twelfth.

INTERCOSTAL CARTILAGES: —

Join true ribs to sternum.

Join false ribs to cartilages of other ribs.

Tip floating ribs.

Vary in direction: first three follow direction of ribs; fourth cartilage forms slight angle with rib; angle increases in acuteness to tenth rib.

INTERCOSTAL spaces follow direction of ribs and cartilages: —

Breadth greater in front and in upper spaces.

RIBS are divided into vertebral extremity, sternal extremity, and shaft: —

Vertebral extremity consists of: —

HEAD, expanded extremity, with kidney-shaped, articular surface divided into two facets for articulation with dorsal vertebra.

NECK, constriction next the head rests on transverse process, has *tuberosity* which has articular facet for articulation with transverse process of dorsal vertebra.

Sternal extremity, oval, surface slightly depressed and rough for fitting of intercostal cartilage.

Shaft, thin, flat; convex externally, concave internally.

External surface shows *angle* where shaft changes its plane of direction. Distance from angle to tuberosity increases from second to tenth rib.

Internal surface shows groove near lower border for intercostal vessels and nerves.

Superior border, thick and round.

Inferior border, thin and sharp.

PECULIAR RIBS.

First, short, flat from above downward, nearly horizontal; no angle; prominent tuberosity.

Second rib resembles first, but has slight angle and curve.

Tenth, **eleventh**, and **twelfth**, single facet.

Eleventh and **twelfth**, no neck, tuberosity, or angle.

SECTION III.— SHOULDER.

Shoulder, bones which connect the arm with the body, *scapula* and *clavicle*.

SCAPULA, triangular, flat bone lying on posterior aspect of thorax, posterior border being parallel to and about two inches from vertebral spines.

Anterior surface, or venter, presents large concave surface,

subscapular fossa, crossed by ridges. This fossa lodges *Subscapularis* muscle.

Posterior surface, or dorsum, is divided into two unequal parts by a transverse ridge, the spine. The smaller part lying above spine is supra-spinous fossa, and lodges *Supra-spinatus* muscle. Part below spine is infra-spinous fossa, and lodges *Infra-spinatus* muscle.

Spine begins at upper third of internal border, and above external border rises to terminate in acromion process. Surface rough for attachment of muscles.

Acromion process, rough projection, protects shoulder joint and articulates with clavicle.

Borders of scapula: —

VERTEBRAL, longest.
AXILLARY, thick and rough. } Both attach many muscles.

SUPERIOR, terminates in coracoid process, at base of which is supra-scapular notch.

Angles: —

SUPERIOR, highest, gives attachment to Lev. Ang. scapulæ.
INFERIOR, thick and rough.
ANTERIOR, irregular, occupied by: —

Glenoid cavity, a shallow, oblong depression for head of humerus.

Neck of scapula, constriction below cavity, to which is attached capsular ligament.

Coracoid process, above and anterior to glenoid fossa, which affords attachment for short head of *Biceps*.

CLAVICLE (a key), resembles letter S. A very elastic, curved bone, extending from top of sternum to acromion process. It acts as a brace to keep the shoulder back and prevent the heavy end of scapula from tilting forward and downward.

Sternal end articulates with sternum and first rib, triangular.

Acromial end, rough for muscles, facet for acromion process.

Shaft, double curve, convex at sternal end and concave at acromial end.

Female clavicle less curved, more slender and shorter than male.

Right clavicle larger than left. May be very prominent in those who perform much muscular labor.

Clavicle often broken, usually by fall on arm or shoulder.

SECTION IV.— UPPER EXTREMITY.

Upper extremity consists of arm, forearm, and hand.

HUMERUS, bone of the arm: shaft and two extremities.

Upper extremity, largest part, consists of:—

HEAD, rounded eminence for articulation with glenoid cavity of scapula.

NECK (anatomical), constriction uniting head and shaft.

GREAT TUBEROSITY, protuberance opposite head for shoulder muscles.

LESSER TUBEROSITY, in front of and below head.

Shaft of humerus cylindrical above, flattened below.

Anterior surface, upper part shows bicipital groove.

External surface, middle part, deltoid eminence.

Posterior surface, musculo-spiral groove, separating attachments of two heads of Triceps.

Lower extremity, flat, curved forward, presents two articular surfaces separated by ridge.

Inner surface (trochlear), broad and grooved, articulating with ulna.

Outer surface, rounded, articulating with radius.

Above articular surfaces anteriorly, two depressions, *coronoid* and *radial*. Posterior articular surface extends into a deep depression, *olecranon* fossa.

To upper edges of these depressions are attached anterior and posterior ligaments of elbow.

CONDYLES (internal and external), projections beyond articular surfaces; internal condyle more prominent.

Internal condyle gives attachment to internal lateral ligament of elbow, and to most of flexor and pronator muscles of forearm.

External condyle gives attachments to external lateral ligament, and extensors and supinators of forearm.

FOREARM consists of ulna and radius.

Ulna (little finger side), largest bone, forms chief part of elbow joint,—shaft and two extremities.

UPPER EXTREMITY, the larger, presents two processes: the large one posteriorly, the olecranon; small one anteriorly, the coronoid.

Olecranon:—

Posterior surface subcutaneous, upper border gives attachment to Triceps and posterior ligament.

Anterior surface, with posterior surface of coronoid,

forms a concave articular surface, the *greater sigmoid cavity*, for trochlear surface of humerus in flexion of forearm.

Small depression in outer side of great sigmoid cavity, the *lesser sigmoid cavity*, receives the head of radius; outer edge rough for orbicular ligament.

SHAFT of ulna prismoid, slightly bent forward and outward.

Anterior surface covered largely by Flexor profundus digitorum.

Posterior surface shows oblique ridge, below which important extensors arise.

LOWER EXTREMITY small, does not enter directly into wrist joint, being separated from carpus by fibro-cartilage; presents rounded surface, the *head* articulating with fibro-cartilage and projecting from inner and lower part, the *styloid process*, to which is attached internal ligament of wrist joint.

Radius (spoke of a wheel), outer side of forearm, rolls around the ulna; chief bone of wrist joint.

UPPER EXTREMITY small, and forms only very small part of elbow joint.

Head rounded, with shallow depression above, articulating with radial surface of humerus. Internally smooth, rotating in lesser sigmoid cavity of ulna.

Neck, constriction below head.

Tuberosity, rough eminence inner side for Biceps.

SHAFT prismoid, narrow above, slightly curved outward.

Anterior surface gives origin to Flexor longus pollicis above, Pronator quadratus below.

Posterior surface, to extensor muscles.

LOWER EXTREMITY large, quadrilateral.

Inferior surface articulates with carpal bones.

Internally small depression, *sigmoid cavity* of radius, for articulation with ulna.

HAND consists of carpus, metacarpus, and phalanges.

Carpus, bones of wrist, two rows (enumerated from radial side).

UPPER ROW, *scaphoid*, *semilunar*, *cuneiform*, *pisiform*.

Scaphoid and semilunar articulate with radius above. All except pisiform, with second row of carpus below.

LOWER ROW, *trapezium*, *trapezoid*, *os magnum*, *unciform*.

Articulate by their upper surfaces with first row of carpus; by their lower surfaces with the five metacarpals.

Metacarpus, five bones (metacarpal), nearly parallel. Articu-

late above with second row of carpus; below with first phalanx of each finger.

CARPAL EXTREMITY, or base, cuboid, articulating on its inferior surface with carpus, and laterally with adjacent metacarpals (except metacarpal of thumb).

DIGITAL EXTREMITY rounded for articulation with phalanges.

FIRST METACARPAL (thumb) shorter and wider than others; does not articulate with adjacent metacarpal; palmar surface faces the others; digital extremely less rounded · has facet for sesamoid bones.

Phalanges fourteen in number,— three to each finger, two to thumb. Decrease regularly in size to tip.

Shaft convex posteriorly, concave anteriorly, rough at sides for sheaths of flexor tendons.

METACARPAL EXTREMITY of phalanges slightly concave.

DIGITAL EXTREMITY of first two, small condyles.

UNGUAL PHALANX pointed and rough.

SECTION V.— PELVIS.

Pelvis, lowest cavity of trunk; upper flaring portion supports, partially, contents of abdomen, and is called "*false pelvis*"; lower portion protects organs of reproduction, and is called "*true pelvis*."

FALSE PELVIS formed by upper part of ossa innominata, and union of sacrum with last lumbar vertebra.

TRUE PELVIS includes all below the line which separates flaring portion from enclosed portion. Opening from false into true pelvis called *pelvic inlet*, lower opening of pelvis the *pelvic outlet*.

Pelvic inlet, bounded by union of last lumbar vertebra with sacrum posteriorly, a prominent line on the hip bones, the *linea ilio-pectinea*, laterally, and the union of the hip bones anteriorly.

Pelvic outlet, bounded by coccyx behind, lowest part of ossa innominata laterally, and union of the two bones (lower border) anteriorly.

It will be noted that in the upright position, owing to the curve of the sacrum, the true pelvis does not lie directly under the false pelvis, but behind it.

OSSA INNOMINATA, two very irregular bones, the hip bones which form the sides and front of the pelvic cavity. Homologous to scapula; connect lower extremity with vertebral column. Each consists of ilium, ischium, pubes,— separate in youth.

Ilium, broad, expanded upper portion.

Superior border, or *crest*, rough ridge extending from anterior superior spinous process, to posterior superior spinous process.

To it attached abdominal muscles and Latissimus dorsi.

Anterior border extends from anterior superior spinous process to anterior inferior spinous process.

Posterior border from posterior superior spinous process to posterior inferior spinous process.

Lower border of ilium, externally, forms upper part of acetabulum.

External surface, or *dorsum*, is irregularly curved, and shows three lines,—superior, middle, inferior. Spaces between these give origin to Glutei muscles.

Internal surface shows smooth concavity anteriorly, the *venter, or iliac fossa*, which lodges the Iliacus muscle. Behind this a rough surface, the lower portion of which presents an auricular surface for articulation with sacrum. Upper part filled by muscles and ligaments. Inferior border of iliac fossa is the ilio-pectineal line.

Below posterior inferior spinous process, ilium shows a deep curve, the *great sacrosciatic notch.*

Ischium forms lower and back part of the bone, divided into body, ramus, and tuberosity.

Body, upper portion; externally forms a large part of concavity of acetabulum; internally forms part of lateral wall of true pelvis. Below, bounded by a large opening, the obturator foramen.

Posterior border marked by a prominent spine, below which is lesser sacrosciatic notch.

Tuberosity rough strong projection, forming lower part; is the part on which body rests in sitting.

Ramus (a branch), extending upward and inward from tuberosity, to meet descending branch of pubes; forms lower boundary of obturator foramen.

Inner surface forms part of anterior wall of pelvis.

Lower border rough, everted; forms part of pelvic outlet.

Pubes, anterior part of ossa innominata, consists of body, horizontal and perpendicular rami.

Body, anterior and inner po. on, from which two rami spring.

Upper border marked by prominent *spine*, the termination of ilio-pectineal line.

Between spine and median line prominent ridge, the *crest.*

Inner border, the union of two pubic bones *symphysis pubes*, presents series of nipple-like projections, into which the fibro-cartilage fits.

From external portion springs horizontal ramus.

From inferior portion descends perpendicular ramus.

HORIZONTAL RAMUS unites pubes with ilium and ischium.

Lower border forms upper border of obturator foramen; outer extremity forms pubic portion of acetabulum.

PERPENDICULAR RAMUS runs downward and outward from body to meet ascending ramus of ischium.

Upper or external border forms internal part of obturator foramen; internal border forms part of pelvic outlet.

Acetabulum, cup-shaped cavity at union of the three bones, for articulation with head of femur. Ilium forms about two-fifths; ischium, two-fifths; pubes, one-fifth.

Bounded by a strong, uneven rim, which serves for attachment of fibro-cartilage.

Inner side cotyloid notch.

Depression for ligamentum teres.

Obturator foramen, large, oval opening below acetabulum. Object, to make bone lighter,—in life nearly filled by obturator membrane.

Margin formed by pubes above, rami of pubes and ischium internally and below, ischium (body of) externally.

Differences between male and female pelvis:—

Male Pelvis.	*Female Pelvis.*
Bones large and massive.	Bones light and delicate.
Iliac fossa more nearly perpendicular.	Iliac fossa more nearly horizontal.
Pelvic inlet heart-shaped.	Pelvic inlet more nearly circular.
Sacrum sharply curved.	Sacrum less curved.
Pubic arch narrow.	Pubic arch wider and edges everted.

SECTION VI.—LOWER EXTREMITY.

Lower extremity consists of thigh, leg, and foot.

FEMUR, or thigh, longest, largest, strongest long bone in body; homologous to humerus. Superior extremity forms, with acetabu-

lum, the hip joint. Inferior extremity forms, with bones of leg, knee joint. It consists of shaft and two extremities.

Upper extremity consists of

HEAD, globular, directed upward, inward, and slightly forward. Smooth, with depression for ligamentum teres.

NECK connects head with shaft. Obliquity varies with age and sex: in woman, nearly right angle; in man, obtuse angle; in childhood, curve upward; in old age, curve downward.

GREAT TROCHANTER, a large, rough prominence on outer side of upper end of shaft, a little below level of head, and beginning at outer end of superior border of neck.

External surface rough for attachment of muscles.

Internal surface deep depression, the digital fossa.

LESSER TROCHANTER lies on inner side of upper extremity of femur, at root of neck.

INTER-TROCHANTERIC LINES, rough line connecting the two trochanters, anterior and posterior; is the line of attachment of capsular ligament.

Important muscles attached around and upon great trochanter.

Six external rotators; namely, two Gemelli, two Obturators, Quadratus femoris and Pyriformis.

Three Glutei; namely, Gluteus medius to top, Gluteus minimus to anterior surface, Gluteus maximus posterior just below base.

To lesser trochanter attached flexors of thigh; namely, Proas and Iliaus.

Shaft of femur cylindrical, slightly convex anteriorly.

Anterior surface smooth for Crureus.

Posterior surface marked by "linea aspera," of which we distinguish, in the middle of shaft, external lip, internal lip, intervening space. In upper part, it divides into three lines, below into two diverging lines, which enclose between them popliteal space.

Muscles attached to linea aspera: —

Outer lip, Vastus externus.
Inner lip, Vastus internus.
Between the lips, three Adductors.
Upper end outer lip, Gluteus maximus.
Upper end inner lip, Pectineus.
Lower end outer lip, Biceps (short head).

Lower extremity flattened antero-posteriorly, and presents

two large articular eminences, outer and inner condyles, separated by depression, which posteriorly becomes inter-condyloid notch.

EXTERNAL CONDYLE most prominent and broadest.

INTERNAL CONDYLE longest, narrowest.

Articular surface extends high in front, behind divided into two parts by inter-condyloid notch, to which are attached crucial ligaments.

TUBEROSITIES, two rough projections from condyles.

Outer on outer side external condyle; inner on inner side internal condyle. To them attached internal and external lateral ligaments of knee joint.

Above condyles attached two heads of Gastrocnemius.

LEG consists of tibia, fibula, and patella.

Tibia (a flute), front and inner side of leg.

UPPER EXTREMITY greatly expanded forms part of knee joint. Consists of two lateral eminences, external and internal tuberosities.

Tuberosities: —

Upper surfaces, two shallow concavities for articulation with condyles of femur. Between these surfaces a prominence, the *spine*, surmounted by two tubercles, to which are attached the semilunar cartilages. In front and behind spine, rough depression for cartilages and crucial ligament.

Anterior surface continuous; at base projection the *tubercle* for ligamentum patellæ.

Posteriorly tuberosity separated by *popliteal notch*.

Internal tuberosity long and oval for internal condyle, has attached internal lateral ligament.

External tuberosity broad and circular for external condyle, marked by articular surface for fibula.

SHAFT prismoid, broad above, narrow in lower fourth, expanding again at lower end.

Anterior border thin and sharp,— subcutaneous, forming *crest*, or shin.

External border has attached above interosseous membrane, at lower part interosseous ligament.

Internal border rounded, smooth.

Internal surface upper third attachment of muscles; lower part subcutaneous.

External surface covered by tendons of muscles to dorsum of foot (mainly extensors).

Posterior surface upper end, oblique line marks limit of Popliteus. Below are attached muscles of plantar surface of foot (chiefly flexors).

LOWER EXTREMITY small, quadrilateral, prolonged down on inner side.

Anterior surface covered by extensor tendons.

Posterior surface rough, deep groove for tendon of Flexor longus pollicis.

Inferior surface smooth for articulation with astragalus.

Exterior surface articular for fibula.

Internal surface prolonged into *internal malleolus* forms inner prominence of ankle. External surface of malleolus deepens articular surface of ankle joint. To its edge attached internal lateral ligament.

Fibula, outer side of leg, small and slender; upper extremity lies below head of tibia. Does not enter into formation of knee joint. Lower extremity inclined forward,—forms outer prominence of ankle joint.

UPPER EXTREMITY, OR HEAD, irregular.

Inner side above, facet for articulation with tibia.

Outer side prominence, to which attached Biceps and long external lateral ligament of knee.

Upper end prolonged above articular surface into *styloid process*, to which attached short external lateral ligament of knee.

SHAFT prismoid.

Anterior surface gives origin to principal extensors.

Internal surface gives origin to principal flexors and interosseous ligament.

External surface gives origin to Peronei.

LOWER EXTREMITY forms *external malleolus*, the outer prominence of ankle.

External surface rough for external lateral ligament of ankle.

Internal surface articular above for tibia, below for astragalus.

Posterior border marked by grooves for Peroneus longus and Brevis.

Patella, or knee-pan, small triangular bone, which slides over anterior articular surface of femur in movements of knee,—protects knee joint. By some regarded as sesamoid bone.

Anterior surface rough, covered by tendon of Quadriceps extensor.

Posterior surface smooth, articular, divided by slight ridge for two condyles of femur.

Superior border thick and rough for Rectus and Crureus.

Lateral border thin for the Vasti; apex gives origin to ligamentum patellæ.

FOOT consists of tarsus, metatarsus, and phalanges.

Tarsus, seven bones placed below and in front of leg, forming heel and posterior part of foot.

First row, *astragalus*, *os calcis*, *scaphoid*, connected with tibia and fibula with astragalus posteriorly; articulates with second row anteriorly.

Second row, *cuboid*, *external middle*, and *internal cuneiform*, connected posteriorly with first row of tarsus, anteriorly with five metatarsals.

Astragalus forms, with tibia and fibula, ankle joint.

Articular surface above, which is prolonged over each side to fit concavity formed by malleoli.

Below rests on os calcis.

Os calcis, largest tarsal bone, forms prominence of heel.

Rough projection posteriorly, to which attached Tendo Achilles.

Inner surface shows deep concavity for plantar vessels, nerves, and flexor tendons.

Scaphoid lies in front of astragalus.

Metatarsus consists of five metatarsal bones strongly resembling metacarpals; distinguished from them by deep groove on plantar surface at tarsal extremity for tendon of Peroneus longus.

First metatarsal (great toe) very large, short, broad, does not face others as thumb. Plantar surface has grooved facets for sesamoid bones.

Fifth metatarsal (little toe) has a large prominence at base externally.

Phalanges same in number as in hand,—fourteen.

First row strongly resembles hand. Articulates with second row of tarsus posteriorly and with second row of phalanges anteriorly.

Second row very small and short, but broad. Ungual phalanges very short and small, but otherwise like hand.

SECTION VII.— SKULL.

SKULL, upper cavity of skeleton. May be regarded as modified vertebræ to receive the brain. Body and processes of vertebræ are represented by base of skull; the intervertebral foramina by the opening for the cranial nerves; while the spinal canal is greatly expanded to receive the brain.

Composed of four vertebræ: occipital, parietal, frontal, nasal (last rudimentary in man); bones all welded together, as motion is not desirable.

Divided into cranium and face.

Cranium (eight bones) forms cavity for brain.

Face (fourteen bones) forms anterior portion.

Bones all immovably united except lower jaw. Such union called a suture.

Bones of external surface of cranium composed of two layers of compact substance, enclosing a varied amount of cancellated tissue. Compact layers known as "tables of skull" (outer and inner).

Divided into five regions:—

First, vertex; second and third, lateral; fourth, base; fifth, face.

Vertex, superior portion of cranium, includes all above a line drawn from nasal eminence to occipital protuberance.

Principal parts named:—

SUPERCILIARY RIDGE,—*external angular process, temporal ridge, superior curved line of occiput.*

External surface smooth, includes greater part of forehead, whole of top of head, and superior portion of occiput.

SAGITTAL SUTURE runs longitudinally across its highest part.

CORONAL SUTURE runs at right angles to the sagittal, over the crown.

LAMBDOIDAL SUTURE posteriorly marks the superior limit of occiput.

Superior curved line of occiput gives attachment to Occipito-frontalis above, and Trapezius below.

Occipital protuberance gives attachment to ligamentum nuchæ.

Lateral regions occupy side of skull.

Anterior limit, external angular process.

Superior limit, temporal ridge.

Posterior limit, superior curved line of occiput.

Inferior limit, the zygoma, outer surface of mastoid process.

This includes part known as temples.

ZYGOMA, an arched ridge, extending from just anterior to ear to meet a similar ridge extending backward from cheek bone. First part known as "zygomatic process of temporal bone"; second part, as "zygomatic process of malar bone."

Posterior end of zygoma, two roots, enclosing between them *glenoid fossa* for lower jaw (inferior maxillary).

In front of anterior root, the *eminentia articularis*, which prevents jaw slipping from socket.

Behind glenoid fossa is *external auditory meatus*, surrounded by *auricular process*, to which is attached cartilage of external ear.

Behind auditory meatus, a rough, round projection, the *mastoid process*, to which is attached the Sterno-cleido-mastoid muscle.

Space between zygoma and main part of skull filled largely with Temporal muscle.

Base of skull.

External surface.

Anterior limit, front, or incisor teeth of upper jaw.

Lateral limit, alveolar process, lower edge of zygoma, and a line drawn from zygoma over tip of mastoid process to superior curved line.

Posterior limit, superior curved line.

On this surface, which is very irregular, we note *alveolar process*, projection for teeth of upper jaw.

Behind this, two oval openings, the *posterior nares*, limited on each side by a long process with two sharp edges bounding a fossa, the *pterygoid processes and fossæ*. Plate of bone dividing the nasal cavity, the *vomer*.

Behind posterior nares, a quadrilateral surface, the *basilar process;* just behind this, two oval projections, the *condyles* for Atlas.

External to condyles, just in front of mastoid process, projects sharp, slender *styloid* process. Under surface mastoid process grooved for Digastric muscle.

Inward from condyles the *foramen magnum*, through which the spinal cord enters the skull. Surface posterior to foramen magnum rough and grooved for attach-

ment of muscles, chiefly those which hold the head erect.

About an inch anterior to superior curved line is seen an *inferior curved line*, to which attached several muscles.

Line from occipital protuberance to posterior edge of foramen magnum, *occipital crest*.

Anterior region, or face.

Superior limit, superciliary ridges, nasal eminence.

Inferior limit, chin.

Laterally, malar bone and ramus of lower jaw.

Contains two cavities for eyes,— *the orbits*.

Upper limit of orbit supra-orbital ridge, toward the inner edge of which is *supra-orbital foramen*, or notch, which transmits supra-orbital vessels and nerves. Cone-shaped, apex being deepest part.

Between the orbits, prominence of nose, ending below is an oval opening, *anterior nares*.

Anterior nares divided into two parts by the vomer, and they communicate directly with posterior nares. Floor of anterior nares is roof of upper jaw.

External to nares and just below lower edge of orbit is *infra-orbital foramen*, transmitting infra-orbital nerve and blood vessels. Depression below, *canine fossa*.

Outward prominence of cheeks formed by malar bones.

Below nares and cheeks, opening of mouth, bounded above by alveolar process of upper jaw (superior maxillary bone), with sockets for teeth.

Space between two sides of alveolar process, a hard ridged surface, the *palatine arch*, or hard palate, the slope of which varies much in individuals.

Lower jaw (inferior maxilla) is lower boundary of mouth and also of face; consists of body and ramus.

Body, horizontal portion, horseshoe form; in median line the symphysis, which ends in projection of chin, *mental process*. From it runs oblique ridge for attachment of muscles of lower jaw. Internal surface concave, and divided by *mylohyoid ridge* for Mylohyoid muscle. In median line two projections, *genial tubercles*. Superior, or alveolar, border contains sockets for lower teeth.

Ramus, or perpendicular portion, joins body at nearly right angles. *Angle of jaw* is the point where infe-

rior border of horizontal portion unites with posterior border of perpendicular.

Exterior surface nearly covered by Masseter.

Interior surface presents a foramen, through which inferior dental nerve and vessels enter jaw.

Inner surface of cranium divided into vertex and base.

Horizontal section shows thickness of cranial bones to differ greatly in different parts, being usually thickest in occipital and frontal regions and thinnest over temples and around foramen magnum.

VERTEX marked by irregularities for convolutions of brain. On each side grooves for middle meningeal artery. Median line shows groove for longitudinal sinus.

BASE OF SKULL divided into anterior, middle. and posterior fossæ.

Anterior fossa extends from inner side of frontal bones to a sharp semicircular ridge which extends from the side inward terminating near the median line in prominent process.

In median line is seen *Crista Galli*, on sides of which is thin plate of bone pierced with holes, the *cribriform plate of ethmoid.*

Forms roof of orbit, and lodges anterior lobes of cerebrum.

Middle fossa lower level than anterior, deeply concave. Terminates behind in a ridge that runs obliquely forward and inward from base of mastoid process.

Central portion irregular, sides deeply grooved for cerebral convolutions.

Lodges middle lobes of cerebrum.

Posterior fossa largest of three and on the lowest plane.

Anterior wall nearly perpendicular, formed by petrous portion of temporal bone, which contains mechanism of internal ear.

In median line anterior wall formed by basilar process.

Upper border corresponds to superior curved line of occiput, and gives attachment to membrane which separates cerebrum from cerebellum, the *tentorium cerebelli.*

Median line prominent ridge, to which is attached membrane separating the halves of cerebellum.

Lodges Cerebellum, Pons Varolii, and Medulla Oblongata.

Behind basilar process, the large oval opening of foramen magnum, through which spinal cord enters cranium. Opening encroached on slightly anteriorly by tubercles for odontoid ligaments.

Most important openings in base of skull named from before backward: —

OPENINGS.	CONTENTS.
1. Cribriform plate of ethmoid,	1st, or olfactory nerve.
2. Foramen opticum,	2d, or optic nerve.
3. Foramen lacerum anterius.	3d, 4th, 5th (1st division), 6th, nerves.
4. Foramen rotundum.	5th (2d division).
5. Foramen ovale.	5th (3d division).
6. Foramen spinosum.	Middle meningeal artery.
7. Foramen lacerum medium.	Carotid artery.
8. Meatus auditorius internus.	7th (facial), 8th (auditory), nerves.
9. Foramen lacerum posterius.	9th, 10th, 11th, nerves. Jugular vein.
10. Foramen magnum.	Spinal cord.
11. Anterior condyloid foramen.	12th nerve.
12. Posterior condyloid foramen.	Veins.

SECTION VIII.— DEVELOPMENT OF BONE.

METHODS OF DEVELOPMENT.

All bones of skeleton, except a portion of skull, are formed in the embryo in cartilage, which later is changed into bone. The bones of the skull, except the base and lower jaw, are developed from a membrane which later becomes periosteum. Endochondral growth, development from cartilage. Periosteal growth, development from periosteal membrane.

Process of ossification, the process by which bone is developed in either of the above ways.

Bones grow in length by endochondral process.

Bones grow in thickness by periosteal process.

Centres of ossification, portion of bone at which the process of ossification starts.

Most bones have several such centres.

Long bones have usually one centre for shaft and one or more for each extremity.

At birth all the shafts of long bones are ossified, but the ex-

tremities are nearly all still cartilaginous, as are also carpus, five bones of tarsus, and coccyx.

Centres of ossification in each extremity of long bone first coalesce and form one mass, which later is united to shaft. Such an extremity is an epiphysis.

Laws of epiphyses.

Do not usually join shaft till adult life, generally twentieth to twenty-fifth year. Usually join shaft in inverse order of development. This order is regulated by direction of nutrient artery of bone.

Section IX.— Cartilage, Etc.

CARTILAGE, tough, glutinous tissue which resembles gelatine. Three kinds, known as: —

1st, **Hyaline**, glistening and semi-transparent, forms surface of joints, costal cartilages, cartilage of nose, larynx, trachea, and bronchi.

2d, **Fibro cartilage**, which is very tough and not transparent. Found in intervertebral disks, interarticular cartilage, sesamoid bones, sacro-iliac, and pubic symphyses.

3d, **Fibro elastic cartilage**, very firm in structure, but contains also many elastic fibres, so that it is capable of stretching. Found in epiglottis, cartilage of ear, parts of larynx.

LIGAMENTS, strong bands of fibres which connect bones with each other, and usually hold the articular surface of a joint in more or less complete apposition. Some ligaments, like the ligamentum nuchæ, have a good many elastic fibres, but usually ligaments are not elastic.

SYNOVIAL MEMBRANE, delicate membrane which encloses the two extremities of an articulation, like a tube, usually lining the ligaments. It secretes a clear fluid, like white of egg, synovia, which acts like oil in keeping the surface of joint moist, and prevents injury from friction.

MUSCULAR TISSUE consists of bands of fibres which have the property of shortening or contracting on the application of a stimulus. Two forms, involuntary, or unstriped, and voluntary, or striped.

Involuntary, or unstriped, found in all parts of body not under control of the will, as in the walls of the stomach, intestines, bladder, uterus, blood vessels, etc.

Pale in color, smooth in appearance, and contractions are generally slow and often long continued.

Voluntary, or striped, found in all parts of the body controlled by the will, as the skeletal muscles, and also in the heart.

Color red; fibres bound in bundles of various shapes and sizes; contraction powerful, sudden, and short.

Each fibre presents a striped appearance, owing to the muscular substance being arranged in alternate light and dark bands.

Each muscular fibre has a delicate covering, the *sarcolemma.*

Bundles bound together by a delicate tissue, the *perimesium.*

Sheath, form of covering which encloses muscles.

Muscles usually have two attachments, origin and insertion.

ORIGIN, the part toward which the motion is made.

INSERTION, the part which moves toward the origin.

Many muscles act from both ends, but for convenience the word "origin" is usually given to the end nearest the trunk.

TENDONS, white, shining bands, or cords, which connect muscles with bones or other muscles. They increase the strength of the union of muscles to the bone, while decreasing its bulk. Tendons, when broad and flat, are often called *aponeuroses.*

AREOLAR, OR CONNECTIVE TISSUE, a delicate, web-like structure which connects the different tissues with each other or different parts of same tissue; found in all parts of body. Serves as connection between skin and muscles, and is then often called *superficial fascia.* The same structure, when thick and firm, forms sheaths for the muscles, and is then known as *deep fascia.*

SECTION X.—HEART AND BLOOD VESSELS.

HEART, organ by means of which the blood is propelled throughout the body. Size, shape, weight, base, apex.

Double organ, having a double office:—

First, to propel blood throughout body (systemic circuit).

Second, to carry it to lungs to be purified (pulmonic circuit).

Heart is double, its two sides (right and left) having no communication with each other.

Each side divided into smaller upper cavity, the auricles, (right and left), lower and larger the ventricles, (right and left).

Auricles receive blood: right auricle from body by vena cava; left auricle from lungs by pulmonary veins.

Ventricles pump out the blood: right ventricle into lungs by pulmonary artery; left ventricle by Aorta all over the body.

Auricles open into ventricles by auricular ventricular opening.

Valves of heart, delicate folds of membrane which guard the various openings, and direct the passage of blood.

TRICUSPID VALVE guards right auricular ventricular opening.

BICUSPID, OR MITRAL, VALVE guards left auricular ventricular opening.

SEMILUNAR VALVES guard aortic and pulmonary openings.

Mitral and tricuspid valves kept from swinging in wrong direction by chordæ tendiniæ.

Course of blood through heart: —

1. Enters right auricle by venæ cavæ (superior and inferior);
2. From right auricle poured in right ventricle (tricuspid valve open);
3. From right ventricle forced into pulmonary artery (tricuspid valve closes, pulmonary semilunar valve open);
4. By pulmonary artery carried to lungs, and from there returned to left auricle by pulmonary veins (semilunar valve closes and prevents return of blood to ventricle);
5. From left auricle flows into left ventricle (mitral valve open);
6. From left ventricle into aorta (mitral valve closed, aortic semilunar valve open).

Structure of heart: —

Muscular substance.

Chief mass of heart muscular fibre arranged in different layers, forming the walls of the cavities: on inner surface of auricular appendages called "musculi pectinati"; on inner surface of ventricles called "columnæ carni" and "papillary muscles."

Muscular walls vary in thickness. Right auricle thinnest, left auricle twice as thick. Right ventricle at least twice as thick as left auricle. Left ventricle three or four times as thick as right ventricle.

All cavities contain about same amount of blood,— namely, three or four ounces.

External covering, *pericardium*, a double membrane, one layer being firmly attached to muscular substance of heart, (visceral layer). This membrane is reflected back from

base, and forms loose bag in which heart is suspended (parietal layer). Serous or sero-fibrous membrane.

Inner lining of heart, *endocardium*, smooth; serous membrane attached to muscular wall of cavities, and forming, by reduplication, the valves of heart.

Action of heart consists in alternate contraction and relaxation of muscular walls.

Mechanism of circulation, or cardiac cycle: —

1st. Auricles fill with blood, right from venæ cavæ, left from pulmonary veins.

2d. Contraction of auricles by which blood is forced through auricular ventricular openings into ventricles.

3d. Tricuspid and bicuspid valves close, and prevent return into auricles.

4th. Ventricles contract, and force blood through aorta and pulmonary semilunar valves into aorta and pulmonary artery.

5th. Semilunar valves close, and after a slight pause the contraction of auricles begins again.

Contraction of cardiac cavities called systole.

Dilation of cardiac cavities called diastole.

Cardiac cycle takes place about 72 times per minute. Time occupied for contraction of auricles, $\frac{1}{10}$ second; contraction of ventricles, $\frac{3}{10}$ second; pause, $\frac{4}{10}$ second.

BLOOD VESSELS, series of tubes by means of which blood is distributed throughout body.

Arteries carry blood from heart.

Have firm, elastic walls; remain open when cut across; blood spirts from them in jets.

Composed of three coats: —

First, *intima*, smooth; composed chiefly of longitudinal elastic fibres.

Second, *media*, elastic; involuntary muscular fibres in varied proportions (chiefly circular).

Third, *adventitia*, fibrous connective tissue.

Veins carry blood to the heart.

Walls thin, but strong; distensible, but not elastic; fall together when cut; blood flows in steady stream.

Composed of three coats similar to artery, but much thinner and very few elastic fibres; furnished with valves.

Capillaries, tiny vessels which connect arteries and veins.

Walls thin; single layer of transparent cells. From $\frac{1}{2000}$ to $\frac{1}{3000}$ inches in diameter. When cut, blood oozes in drops.

Walls so thin that fluid parts of blood transude through them.

SECTION XI.—PRINCIPAL ARTERIES OF BODY.

NAME.	DISTRIBUTION.
ARCH OF AORTA,—from upper right-hand corner of right ventricle to left side of body of fourth dorsal vertebra:—	
1. Coronary.	Walls of heart.
2. Innominata.	
1. Right common carotid.	
1. Internal carotid.	Anterior and middle lobes of brain.
2. External carotid.	Face; surface of cranium; membranes of brain; upper part neck.
2. Right subclavian.	Lower part neck; anterior wall thorax (by internal mammary); posterior part brain (by vertebral); shoulder; first two ribs (superior intercostal).
3. Left common carotid.	As on right side.
1. Internal carotid.	As on right side.
2. External carotid.	As on right side.
4. Left subclavian.	As on right side.
THORACIC AORTA,—from fourth dorsal vertebra to diaphragm:—	
1. Bronchial.	To lungs.
2. Intercostals (10).	To chest walls.
3. Pericardial.	To pericardium.
ABDOMINAL AORTA,—from diaphragm to fourth lumbar vertebra:—	
1. Phrenic.	To diaphragm.
2. Cœliac axis.	
Gastric.	To stomach, liver, spleen, pancreas, and gall bladder.
Hepatic.	
Splenic.	
3. Superior mesenteric.	To pancreas, small intestines, large intestine, upper part.
4. Renal.	To kidneys.
5. Spermatic or ovarian.	To testes or ovaries.
6. Inferior mesenteric.	To large intestine.
ARTERIES OF UPPER EXTREMITY. Subclavian becomes axillary after passing first rib:—	
Axillary, from first rib to lower border Teres Major.	To axilla, lateral wall of thorax, shoulder joint and scapula.
Brachial, from Teres Major to one-half inch below elbow.	To arm (posterior surface supplied by Superior Profunda).
1. Ulnar, from bend of elbow to palm (ulnar side), terminates in superficial arch.	To elbow joint; ulnar side forearm and hand; posterior side (by posterior interosseous); fingers (except first and second).

2. Radial, from bend of elbow to palm of hand (radial side); forms deep palmar arch.	To elbow joint, forearm, and hand (radial side), thumb, and radial side index finger.

PRIMARY DIVISIONS OF AORTA,—at fourth lumbar vertebra:—

Right Common Iliac.	
1. Internal Iliac (right).	Pelvic organs, posterior part hip and thigh.
2. External Iliac (right).	Muscles of abdomen and pelvis.
Left Common Iliac.	Same as right.

ARTERIES OF LOWER EXTREMITY. External Iliac becomes Femoral on leaving pelvis:—

Femoral, from edge of pelvis to opening in Adductor magnus.	Superficial fascia of thigh abdominal and external genitals; anterior surface of thigh; knee joint.
Profunda Femoris.	Hip joint; posterior muscles of thigh.
Popliteal, from Adductor magnus to lower border Popliteal.	Knee joint, muscles of calf, and lower extremities of thigh.
1. Anterior Tibial to annular ligament.	Anterior surface of leg, ankle joint.
Dorsalis Pedis.	Dorsum of foot; plantar surface first and second toe.
2. Posterior Tibial to behind inner malleolus.	Posterior surface of leg, tibial side.
Peroneal.	Fibular side of leg.
Posterior Tibial divides into	
1. Internal plantar.	Internal side of foot.
2. External plantar, forms with Dorsalis Pedis plantar arch.	Plantar surface of foot and toes except as above.

SECTION XII.—VEINS.

Veins begin at periphery, and converge towards heart. Deep veins follow arteries, and usually have same name. Often two accompany an artery, communicating at intervals by cross branches. These are known as "venæ comites." Superficial veins lie directly under skin, and have no accompanying arteries. They empty into deep veins.

VEINS OF CRANIUM, NECK, AND FACE form Internal and External Jugular, which unite with veins of upper extremity to make Venæ Innominata.

VEINS OF UPPER EXTREMITY.

Deep veins accompany Radial, Ulnar, Brachial, Axillary, and Subclavian arteries, Subclavian vein joins Interior Jugular to make Innominata.

Superficial veins of upper extremity form Cephalic (radial side) and Basilic (ulnar side). Basilic enters brachial or axillary; Cephalic joins axillary.

Union of right and left Innominata make Vena Cava Superior.

VEINS OF LOWER EXTREMITY.

Deep veins accompany Plantar, Tibial, Popliteal, and Femoral arteries.

Superficial veins of anterior and inner side of foot, leg, and thigh form Long or Internal Saphenous. Those of posterior and outer side of foot and leg form External or Short Saphenous.

Internal Saphenous joins Femoral; External Saphenous joins Popliteal.

VEINS OF TRUNK BELOW HEART.

Veins of same name accompany External Iliac, Internal Iliac, and Common Iliac arteries.

Right and left Iliac veins unite to form Vena Cava Superior.

Vena Cava Inferior receives also blood from abdominal organs through liver by hepatic veins.

Venæ Azygi connect Vena Cava Superior with Vena Cava Inferior. Empty into former.

Receive intercostal and bronchial veins.

Relation of arteries and veins to capillaries:—

Capillaries everywhere make connection between arteries and veins. (Exceptions,—tips of fingers and toes, bed of nails, tip of ears and nose.)

Form a network which penetrates nearly every part of the body, forming the link between arteries and veins.

Smallest capillaries, in nervous system; largest, in marrow of bone. None in transparent parts of eye, cartilage, nor in some parts of bone.

Walls of capillaries, layer of transparent, flat, polygonal cells, cemented together by their edges.

SECTION XIII.—PHYSIOLOGY OF CIRCULATION.

FORCES THAT MOVE BLOOD.

First, **Contraction of muscular walls of heart**, sufficient in itself to drive the blood throughout the body.

Repeated on an average 72 times per minute.

Action involuntary, but may be greatly modified by external circumstances.

Modified by (*a*) age; (*b*) sex; (*c*) position; (*d*) exercise; (*e*) mental emotion.

Causes of contraction, nerve stimulation from nerve centres in cardiac walls; inhibited by pneumogastric; accelerated by sympathetic (cardiac plexus).

Second, **Contraction of walls of blood vessels**; acts chiefly in arteries.

Third, **Aspiratory force of thorax.**

Difference in atmospheric pressure between external surface of body and inside of thorax causes blood to be sucked into thorax during inspiration.

Fourth, **Muscular movement**; acts chiefly in veins.

Fifth, **Gravity**; acts in veins above heart, and in aorta (lower part).

FACTORS THAT MODIFY CIRCULATION.

Blood pressure, the pressure that the blood exerts on the walls of the blood vessels in its passage through them.

High in arteries; diminishes rapidly in capillaries; very low in veins; often negative in vena cava.

Amount dependent on: —

First, FORCE AND FREQUENCY OF VENTRICULAR SYSTOLE.

Second, PERIPHERAL RESISTANCE met with in capillaries and small arteries.

Peripheral resistance dependent on: —

(1) Increased friction met with in capillaries;

(2) Condition of blood in vessels;

(3) Vaso-motor influence on calibre of smallest arteries.

Intermittent flow in arteries changed to continuous flow in capillaries and veins.

Rapidity of flow; greatest in arteries, least in capillaries, intermediate in veins.

SECTION XIV.—BLOOD.

BLOOD, fluid which is contained in blood vessels by means of which all parts of the body are nourished.

Description,—opaque, red fluid; reaction alkaline; specific gravity, 1.055.

Composition: —

First, Plasma, or liquor sanguinis, the fluid portion.

Second, Blood cells, or corpuscles, small bodies which float in the plasma.

Chemical composition of 1,000 parts blood: —

Plasma, 672.	Water,	604	Cells, 328.	Water,	200
	Fibrin,	7		Hæmoglobin,	116
	Albumen,	52		Salts,	2
	Fat,	1		Other constituents,	10
	Organic matter,	3			
	Salts,	5			

Cells (red), small bi-concave disks of protoplasm; color, pale yellow; diameter, $\frac{1}{3500}$ inch; no visible nucleus nor cell membrane.

Chief constituent hæmoglobin, a proteid, which has the power of taking up and giving off oxygen. Contains coloring matter and iron.

Salts: most important those of potash.

Cells have tendency to adhere together in piles. Number in health, 5,000,000 red cells to one cubic mm.

Origin; marrow of bone, possibly spleen.

Cells (white), round masses of granular protoplasm, showing nucleus and amaboid movement; diameter, $\frac{1}{2500}$ inch; colorless. Proportion to red, 1 to 300 or 500.

Plasma, constituents of: —

Albumen, clear, gelatinous substance, resembling white of egg. Very important in nutrition of tissues.

Fibrin, delicate yellow threads or fibres formed in clotted blood, the process of clotting or coagulation being that the blood cells are caught in meshes of the fibrin. Believed to be due to a ferment called "fibrin ferment," acting on two constituents of blood known as paraglobulin and fibrinogen.

Serum is the plasma minus the elements of fibrin.

Salts: most important sodium chloride.

Coagulation of blood very important in stopping hemorrhage. Does not clot in healthy blood vessels during life; if vessels are injured or diseased, may take place.

Circumstances influencing outside of body: —

Delayed or destroyed by —

Temperature over 50° C., freezing, certain chemicals.

Hastened by —

Agitation, large surface, nature of surface.

Section XV.—Lungs.

Lungs, organs whose office is to expose the blood to the air for purification.

Shape conical, apex pointed, base concave for diaphragm.

Anterior border thin and sharp. Below shows notch where heart's apex is seen.

Posterior border rounded and thick.

External surface convex, and shaped to correspond to thoracic wall.

Internal surface concave, to accommodate heart.

Whole surface covered by pleura.

Partially divided by clefts into lobes.

Color pink in childhood, gray and mottled in adults.

Air conveyed to lungs through nose, mouth, pharynx, larynx, trachea, and bronchial tubes.

Only trachea and bronchial tubes have this work as their sole office.

Trachea, straight tube, consisting of rings of cartilage connected by bands of elastic and muscular fibre.

Cartilages keep tubes open; incomplete posteriorly.

Lined with mucous membrane.

Lies in front of œsophagus on bodies of vertebræ, from fifth cervical to third dorsal, and there divided into right and left bronchi.

Bronchi,—one for each lung, right shorter; divide and subdivide into numerous bronchial tubes.

Structure similar to trachea, except that cartilage is in plates, not rings.

Smallest bronchial tubes have no cartilage, and are called bronchioles.

Bronchioles terminate in expansions known as *infundibula*, walls of which are formed of pulmonary air cells.

Pulmonary artery and pulmonary veins accompany bronchial tubes throughout lungs.

Branches of pulmonary artery terminate in capillaries at infundibula. These capillaries ramify on outside of pulmonary air cells.

Walls of capillary and air cells are so thin that blood is exposed freely to air.

Pulmonary veins originate from these capillaries, and carry purified blood back to heart.

Terminal bronchus, with its infundibula, arteries, and veins, constitutes a pulmonary lobule.

Structure of lung may be said to be made up of vast numbers of these lobules, held together by connective tissue.

Pulmonary artery, pulmonary veins, bronchus, bronchial artery and vein, and pneumogastric nerve, all enter lung at same place, and make the "root of the lung."

SECTION XVI.—THORAX.

THORAX, a closed cavity, the bony walls of which are covered with muscles. Inner surface covered with pleura costalis, which is reflected over surface of lungs at the roots, and there called pleura pulmonalis.

Walls elastic, from costal cartilage, which completes it anteriorly.

Lower limit, upper surface of diaphragm also covered with pleura.

In health, pleura costalis and pulmonalis are in contact, the lungs filling the whole thorax, except part occupied by heart, great vessels, and œsophagus.

Heart lies chiefly on left side, highest portion between third and fourth rib. Apex approaching chest wall between fifth and sixth rib and about two inches left of sternum.

Its posterior surface rests on diaphragm.

SECTION XVII.—RESPIRATION.

RESPIRATION (pulmonary), which takes place in the lungs, is the process by which the O of air replaces the CO_2 of blood.

This is accomplished by the alternate expansion and contraction of the thoracic walls, by which air is drawn into and expelled from lungs.

Mechanism consists of two acts:—

Inspiration, drawing in air.

Expiration, expelling air.

Both involuntary, but may be greatly modified by will.

Enlargement of thoracic walls in inspiration accomplished by:

(1) Elevation of ribs,
(2) Descent of diaphragm, } both by muscular action.

Principal muscles engaged in tranquil inspiration:—

Intercostals (External and Internal), Diaphragm.

Action of Intercostals enlarges cavity laterally and anteriorly.

Diaphragm, muscular partition separating chest and abdomen.

Two parts:—

Perpendicular, attached to lumbar vertebræ.

Horizontal, dome-shaped, attached to sternum, edges of ribs 7th to 12th, and lumbar vertebræ.

Convexity toward thorax, concavity toward abdomen.

Action in inspiration: descends till convex surface approaches a plane, lungs follow its movement, abdominal organs descend, and abdominal walls expand.

Action in expiration: relaxation of muscular fibres, and

return to former position, lungs expel air, and abdominal organs resume their former level.

Retraction of chest in ordinary expiration is accomplished by relaxation of the inspiratory muscles and elasticity of lungs. Very little, if any, muscular action except in forced expiration.

(Special description of various muscles of respiration and their action belongs to the lecturer on muscles of the skeleton.)

Length of inspiration compared with expiration, 6–8.

Lung capacity: —

RESIDUAL AIR, that which never leaves lungs (100 cubic inches).

RESERVE AIR, that which can be expelled after an ordinary expiration (110 cubic inches).

COMPLEMENTAL AIR, that which can be inspired after an ordinary inspiration (110 cubic inches).

TIDAL AIR, volume inspired and expired with each ordinary respiration (20 cubic inches).

VITAL CAPACITY = reserve + complemental + tidal.

Normal mechanism of respiration requires,—

Free mobility of chest walls and diaphragm.

Mobility of chest walls impeded by —

Tight clothing,
Faulty position,
Feeble inspiratory muscles,
Want of elasticity of costal cartilage.

Descent of diaphragm impeded by anything that limits the free movement of abdominal walls, such as tight bands and belts, long corsets, etc.

Chemistry of respiration.

Expired air as compared with inspired air: —

Has lost oxygen.
Has gained carbonic acid.
Has increased in temperature.
Has gained moisture.
Contains ammonia and organic impurities, the latter even more poisonous than CO_2, and supposed to belong to class of ptomaines.

	O	CO_2	N
Pure air contains	20.81	.04	79.15
Expired air contains	16.03	4.38	79.58

Difference between atmospheric air and air in air cells,—

Always less O and more CO_2 in air deep in lungs than in larger bronchi, but the difference is partially equalized; —

By law of diffusion of gases,
By action of the cilia of bronchial tubes.

Relative amount of O and CO_2 varies greatly with exercise, food, temperature, age, sex, etc.

Respiratory changes in blood.

Change in color: blood in pulmonary arteries, bluish; blood in pulmonary veins, bright red.

Change in composition: arterial blood contains from 8–12% more O and 6% less CO_2 than venous.

Amount of O in arterial blood tolerably constant; amount of CO_2 in venous blood varies greatly in different veins and at different times in same veins.

Condition of O in blood,— mostly found in red corpuscles in combination with hæmoglobin, as *oxyhæmoglobin*, by reason of great affinity that hæmoglobin has for O. It remains thus combined till the arterial blood reaches the capillaries, where the tissues have a still greater affinity for O, and therefore take it from the blood, leaving the hæmoglobin reduced.

Condition of CO_2 in blood not clearly known; supposed to exist in combination with salts of plasma.

Normal oxygenation of blood requires

A constant supply of fresh, pure air to pulmonary air cells;

A regular and free passage of blood from right side of heart through lungs back to left auricle.

Effect of atmospheric pressure.

High altitudes, as top of mountains, difficult to absorb enough O for wants of tissues.

Effects are congestion of skin, rapid heart action, dyspnœa, muscular weakness, and faintness.

Low altitudes (below surface of earth), skin pale, respiration and heart's action slow, inspiration easy, expiration difficult.

VENTILATION.

SECTION XVIII.—ABDOMEN.

ABDOMINAL CAVITY formed by diaphragm superiorly, inlet of pelvis inferiorly, lumbar vertebra behind, abdominal and lumbar muscles forming greater part of anterior, lateral, and posterior walls. In upper portion the lower ribs help to enclose it anteriorly and laterally, while below its contents are further supported by flaring sides of the iliac bones.

Walls of cavity lined with peritoneum, which also forms a more or less complete covering of all the abdominal organs except

the kidneys. It also forms folds by which the organs are held in place.

ORGANS OF ABDOMEN:—

Stomach, small intestines, large intestines (alimentary canal), liver, gall bladder, pancreas, spleen, kidneys.

Stomach, large pouch having two openings, *cardiac* at large, or upper end, *pyloric* at lower, or intestinal end.

Lies close under diaphragm and behind anterior portions of ribs on left side, its pyloric extremity reaching a little to right of median line.

When distended, may extend below ribs and far to right of median line.

From lower border depends a fold of peritoneum, the great omentum.

Small intestine, tube of twenty feet in length, extending from pyloric opening of stomach to ileo-cæcal valve; divided into *duodenum*, *jejunum*, and *ileum*,— lies coiled in centre of abdomen, and held in place by the mesentery, which attaches it loosely to lumbar vertebrae.

Large intestine opens from small intestine at right angles through ileo-cæcal valve about level of right antero-superior spinous process of ilium, and forms an arch around small intestine till it reaches lower edge of left iliac fossa, where it descends into pelvis (*sigmoid flexure*).

Divided into *cæcum*, *colon*, and *rectum* (latter in pelvis).

Held more or less firmly in place by folds of peritoneum, called meso-cæcum, meso-colon, and meso-rectum.

Liver, large brown gland, occupying space between diaphragm and lower ribs on right side. Its left extremity crosses median line to edges of ribs on left side.

In deep inspiration it extends below the ribs.

It is connected with the duodenum by the *ductus communis choledochus*.

Pancreas, long, narrow gland, extending transversely across the posterior part of the abdomen, behind the stomach.

Its small end, or tail, rests on the spleen. Its large end, or head, fits into the curve of the duodenum, into which its duct opens with that of the liver.

Spleen, dark colored, flat organ, lying to left of stomach and against lower ribs.

Connected with stomach by a fold of peritoneum, the *lesser omentum*.

Kidneys lie on posterior abdominal wall on each side of the

lumbar vertebræ from the level of eleventh rib to third lumbar vertebra.

Right kidney slightly lower than left. Lie behind peritoneum. From concave border, a tube, the *ureter*, leads into the bladder.

SECTION XIX.—ALIMENTARY CANAL.

ALIMENTARY CANAL is the place into which food is received, its nourishing parts digested and absorbed, and from which the waste is excreted.

Extends from mouth to anus, and is a modification of the simple tube which serves the same purpose in lower animals.

Divided into *mouth*, *pharynx*, *œsophagus*, *stomach*, *small and large intestines.*

Structure; mucous coat, muscular coat, peritoneal coat.

Mucous membrane lines it throughout. Contains the glands and blood vessels.

Muscular coat composed of muscular fibre, arranged in various directions. Muscular fibres voluntary in mouth, pharynx, and upper part of œsophagus. Involuntary below diaphragm. Contraction of these fibres propels through food canal.

Peritoneal coat covers muscular coat in parts below diaphragm. Smooth and moist, to prevent friction in movements.

Mouth, organ of prehension, mastication, and insalivation. These acts performed by muscles of mastication, aided by lips, teeth, and tongue. Into it open salivary glands

Pharynx, passage from mouth to œsophagus.

Œsophagus, straight tube lying in front of vertebrae from pharynx to cardiac orifice of stomach. Forms passage for food.

Stomach, dilatation of the digestive canal for retention of food to subject it to action of digestive fluid.

Shape, orifices, curvatures, direction of muscular fibres, movements.

In mucous membranes lie the glands which secrete gastric juice.

Small intestines, muscular fibres arranged in an outer or longitudinal and inner or circular layer. Alternate contraction and relaxation of these layers push food on.

Mucous membrane contains glands that secrete intestinal fluid. Into it are poured bile and pancreatic secretion.

Large intestines chiefly for excretion of waste. Diameter larger than small intestines. Muscular fibres longitudinal and circular, but former arranged in bands which increase their power.

SECTION XX.—DIGESTION.

DIGESTION, the process by which the nourishing parts of the food are changed into fluids which can be absorbed into the blood.

Different parts of alimentary canal digest different classes of food.

Each part has its own secretion and its own peculiar movements, by means of which the food is brought in contact with the secretion.

A secretion is a fluid manufactured out of the blood, to be used for some special purpose. Secretions usually manufacture in organs called glands.

GLANDS are manufactories whose cells have the power of taking certain substances out of the blood and making them into a new fluid for special use.

Foods,— classes: —

1. PROTEIDS, containing nitrogen.
2. STARCHES and SUGARS (contain C, H, and O).
3. FATS (contain C, H, and O).
4. WATER and SALTS.

The first three require to be digested before they can be absorbed. The fourth require no digestion.

Changes in different foods by digestive fluids: —

1. Proteids changed to peptones.
2. Starches and sugars to grape sugar.
3. Fats emulsified.

Most foods contain several of these classes, and must therefore be acted upon by several digestive fluids before digestion is completed.

Four separate parts of canal which have each their special work in digestion: —

1st, MOUTH DIGESTION.

Secretion, *saliva* from salivary glands.

Digestive action, changes starch into sugars.

Mouth digestion feeble and of minor importance.

Saliva more to moisten food than digest it.

Mechanical action, movements jaws, lips, and teeth.

2d, STOMACH DIGESTION.

Secretion, *gastric juice*, from gastric glands.

Digestive action: changes proteids into peptones; changes cane sugar into grape sugar.

Mechanical action, contraction of muscular walls of stomach, churn food about, till it becomes semi-solid mass called chyme.

3d, DIGESTION IN SMALL INTESTINES.

Secretions, *pancreatic juice* from pancreas, *bile* from liver, *intestinal secretion* from glands of intestines.

Digestive action: —

(*a*) Pancreatic secretion changes proteids into peptones; starch into sugar; emulsifies fat.

(*b*) Bile antiseptic, stimulant to muscular action, aids in emulsifying fat.

(*c*) Intestinal secretion has feeble action on all classes.

Mechanical action, peristaltic movements from contraction of muscular coat.

4th, DIGESTION IN LARGE INTESTINES.

Secretion, *intestinal secretion* from intestinal glands, action very feeble. Large intestines intended to excrete waste, but in case of need, their digestive power may be used.

Mechanical action, same as small intestines.

Digestion influenced by many circumstances (mouth and stomach digestion chiefly).

Conditions relating to food: —

(*a*) Temperature; (*b*) dilution; (*c*) division; (*d*) amount of indigestible matter.

Conditions independent of food: —

(*a*) Muscular exercise; (*b*) intellectual work; (*c*) sleep; (*d*) condition of nerves.

All classes of food necessary to a healthy nutrition, but proportions vary with age, occupation, habits of life, etc.

Digestibility and nutritive power of food not synonymous. Both must be considered in preparing a suitable diet.

(Digestive food tables, showing proportion of each food class and average time of digestion for the ordinary articles of diet.)

SECTION XXI.—ABSORPTION AND NUTRITION.

ABSORPTION, the process by which digested food is carried into blood.

Takes place from all parts of alimentary canal, but chiefly from stomach and small intestine.

Channels of absorption:—

Into capillary vessels.

Into lymphatics.

Both eventually carry the digested food into the general circulation.

Absorption from stomach into capillaries, which approach the surface between the gastric glands.

Absorption from intestines through intestinal villi.

Villi, slight projections from mucous membrane of small intestine, each containing blood vessels and lacteals.

Food absorbed into them carried to larger blood vessels and lymphatics at base.

Food classes absorbed:—

Peptones, grape sugar, water, and salts usually absorbed into capillaries.

Emulsified fats by lacteals of intestinal villi.

NUTRITION, the process by which materials carried in the blood are used to build up and repair the various tissues of the body.

Capillary blood vessels penetrate more or less freely between the elements of nearly all the tissues. Their liquid contents are largely exuded into the crevices between the tissue elements, so that the latter are constantly bathed in nutritious liquid, called lymph. From this liquid the various tissues seem to have a selective power, whereby they take what is suitable to each. The remainder is carried away by the lymphatics, into which also are poured many of the worn-out products of tissue waste.

SECTION XXII.—LYMPHATICS.

LYMPHATICS, name given to series of tubes which are found all over the body and whose office is to carry lymph.

Lymphatic vessels accompany the blood vessels everywhere, collecting lymph from all the tissues and pouring it into veins.

Main lymphatic vessel of body, *thoracic duct*, which extends from second lumbar vertebra to neck, where it empties into left internal jugular near juncture with left subclavian.

Lymphatics from right side head, neck, upper extremity, thorax, right lung, and the heart, empty into smaller duct which enters right internal jugular vein.

Principal lymphatic vessels run through lymphatic glands before entering main ducts.

Seat of most important lymphatic glands: —

Beneath chin, occiput (base of), neck (behind Sterno-cleido-mastoid), axilla, groin, and in connection with internal organs as mesenteric bronchial.

Structure of lymphatics: —

Large ones resemble veins; have valves.

Smallest resemble capillaries.

Lymphatic spaces, irregular channels in interstices of connective tissue; contain lymph.

By means of them the tissue elements are bathed in lymph.

Lymph is liquor sanguinis, to which are added lymph corpuscles, derived chiefly from lymphatic glands.

Lacteal lymphatics contain chyle.

Lymphatics carry lymph where blood cannot go, as cornea of eye.

Liquor sanguinis exudes into lymph spaces from capillaries, tissues appropriate what they need, and surplus is carried off by lymphatic capillaries, together with various products of tissue waste.

Serous cavities are believed to be enormous lymph spaces.

When lymph is not removed, it collects in tissues and cavities, causing dropsy.

Movements of lymphatics always toward heart.

Causes of; — muscular movement.

Suction into veins during inspiration.

Difference in pressure between lymphatics and veins near heart.

SECTION XXIII.—PELVIC ORGANS (FEMALE).

PELVIS contains organs of reproduction, bladder, and rectum.

Organs of reproduction: —

OVARIES, organs in which ovum is formed and ripened.

Consists of a firm network of fibres holding thousands of ova.

Ova formed in ovary at birth, but do not change or ripen till the time of maturity.

From time of development to forty-five or fifty years of age

ova are constantly ripening and approaching the surface of the ovary, from which they are discharged.

Later in life the ova cease to ripen, and the ovary gradually shrinks up and becomes useless.

UTERUS, organ in which ovum is developed; pear-shaped, larger end (body) above, smaller (neck) below. Three inches long. Walls firm; composed largely of involuntary muscular fibre.

Cavity, an isosceles triangle, lower angle being the mouth, the two upper opening into the tubes.

Lining of cavity, a modified mucous membrane.

FALLOPIAN TUBES, the passages by which ova reach uterus; two twisted narrow tubes about four inches long, leading outward from superior angles of uterine cavity.

Diameter of tube very small, but expanded at both extremities.

Outer extremity trumpet-shaped, and bordered by fringes, or fimbriæ.

VAGINA, passage with muscular walls, which embraces the neck of the uterus above, and opens externally below.

It is the channel by which the ovum is discharged externally.

Ovum when ripe projects from the surface of the ovary, and in this condition is grasped by the fimbriæ of the Fallopian tubes, so that, when discharged, it falls into the tube and is gradually propelled into the cavity of the uterus.

If, during its passage, it is fertilized, it embeds itself in the uterine wall and grows there.

If not fertilized, it dies, and passes away unseen.

Bladder, reservoir for urine.

Lies anterior to uterus. When empty, is entirely within the pelvis, but, when full, rises above the symphysis.

Discharges its contents externally by a narrow passage, the meatus urinarius.

Rectum, termination of alimentary canal.

Passes through pelvis, lying on the left of the median line and posterior to uterus; terminates in median line, its outer opening, the anus, being guarded by a strong sphincter muscle.

Organs of pelvis fastened to each other and held in position chiefly by folds of peritoneum enclosing a few involuntary muscular fibres and known as ligaments of the pelvis.

Broad ligaments most important; triangular folds stretching

from sides of uterus to pelvic walls; in upper border run Fallopian tubes; from posterior surface project the ovaries; between folds, blood vessels and nerves reach the uterus, tubes, and ovaries.

Other ligaments bind bladder to uterus, uterus to rectum, and rectum to pelvis.

Blood vessels of uterus and ovaries.

Arteries, corkscrew like, called helicine. Veins very numerous. Walls fastened to muscular fibres, so they cannot collapse. No valves. Object, to accommodate growth of organs during pregnancy.

GROWTH AND DEVELOPMENT OF REPRODUCTIVE ORGANS.

At birth very small, and remain so till near age of puberty, then begin to grow so rapidly that within a year or two they attain their full size and functions.

Approaching maturity distinguished by both mental and physical changes in a young girl.

Complete maturity manifested by appearance of the menses.

Menstruation, or monthly flow, a periodical hemorrhage, produced by rupture of the numerous capillaries on inner wall of uterus, caused by their over-distention from a congestion of all the pelvic blood vessels.

Reason of menstruation,— pelvic organs supplied with more blood than they need for their own nutrition, to provide for the growth of the ovum. When there is no ovum to develop, the extra blood is discharged as the menstrual flow.

Time of menstruation supposed by many to correspond to the approach of an ovum to surface of ovary,— not proven.

Age of maturity or puberty differs with climate, social environments, habits of life, etc. In this climate averages thirteen to sixteen.

Period of development, critical time for young girl.

Growth of organs so rapid that they must have a plentiful supply of healthy blood.

If the blood is not healthy or is diverted elsewhere, the organs are poorly developed and never perform their function well.

Principal causes of imperfect development, mental and physical overwork, bad air, poor food, over-stimulation by social excitement, sensational novels, artificial life.

Connection of pelvic organs with nervous system intricate and important.

Insufficient or irregular development manifests itself by pain or some form of nervous excitement, commonly by both.

Especial disposition among American girls to all forms of nervous derangements. Foundation of these often laid by improper care at puberty.

Menstruation a natural process and, in a healthy, well-balanced person, should cause no interference with the ordinary habits of life; but, in this age and country, few are so absolutely healthy that they can entirely disregard it.

Precautions,—avoidance of excessive mental or physical work.

If period painful, least possible exercise. If excessively painful, absolute rest.

Effects of position on circulation in pelvis; peculiar conditions of circulation render venous stasis very liable to occur; effect of standing, sitting, lying, walking, on circulation.

Effect of faulty positions on health of pelvic organs.

SECTION XXIV.—NERVOUS SYSTEM.

Complete nervous circuit consists of, 1st, an efferent nerve fibre which conveys a nerve impulse from the periphery to a nerve centre; 2d, a nerve cell, the source of nerve power; 3d, an efferent fibre which conveys the impulse generated in the nerve centre to the periphery.

Nerve fibres are simply receivers and conductors of nerve impulses.

Two kinds, white and gray.

White nerve fibre consists of:—

(1) An outer delicate membrane (neurilemma).

(2) An intermediate soft white layer (white *substance of Schwann*, or medulla).

(3) Central gray fibre, or *axis cylinder*.

The axis cylinder conducts the nerve impulse; the medulla protects and insulates the axis cylinder; the neurilemma keeps fibre in shape.

Gray nerve fibres have only axis cylinder and neurilemma.

Nerves are collections of nerve fibres bound together in bundles by connective tissue, the whole surmounted by a sheath.

Nerve cells distinguished by projections called poles, and ac

cording to number of poles are called "apolar," "bipolar," "multipolar," etc. From these poles extend delicate gray fibres which connect them with poles of other cells, or with axes cylinders.

Collection of nerve cells often called *ganglion.*

HUMAN NERVOUS SYSTEM consists of: —

1. **Cerebro-spinal** system (brain, spinal cord, cerebral and spinal nerves).
2. **Sympathetic** system (sympathetic ganglia and nerves).

Cerebro-spinal system controls all voluntary and intellectual acts, and partially the work of many internal organs.

Brain and spinal cord contain nerve centres, to and from which all nerves run (afferent and efferent).

Nerves are composed entirely of white fibres.

Nerves conveying sensory impulses only, called "sensory nerves" (fibres all afferent).

Nerves conveying motor impulses only, called "motor nerves" (fibres all efferent).

Nerves conveying both sensory and motor fibres are "mixed nerves" (fibres both afferent and efferent).

Spinal nerves (31 pairs), all mixed nerves. Afferent and efferent fibres run in same sheath, except at two extremities.

Central end; afferent and efferent fibres separate just within intervertebral foramen, afferent fibres forming posterior nerve root and entering posterior part of cord, efferent fibres coming from anterior part of cord and forming anterior nerve root.

Posterior root further distinguished by a small ganglion.

Peripheral end; — sensory nerve terminations in skin. Axis cylinder of each fibre splits into fibrillæ, each of which connects itself with cells of derma.

Special endings in tips of fingers and toes, palms of hands, tongue, etc.

Motor nerve fibres end chiefly in "muscle plates."

Spinal nerves divided into: —

8 pairs cervical.
12 pairs dorsal.
5 pairs lumbar.
5 pairs sacral.
1 pair coccygeal.

} Each nerve on leaving internal vertebral foramen divides into anterior and posterior branches; posterior branch small, anterior branch gives off chief nerves to trunk and extremities.

Nerve plexuses, union of branches of several nerves from which other nerves are given off to special regions.

SECTION XXV.—SPINAL NERVES AND THEIR DISTRIBUTION.

CERVICAL PLEXUS (1st, 2d, 3d, and 4th cervical).
Muscles and skin of occiput, neck, back of ear, shoulder (upper part), diaphragm.

BRACHIAL PLEXUS (5th, 6th, 7th, 8th cervical, 1st dorsal).
Muscles of chest (Pectorales), scapula (partially), shoulder joint, upper extremity.

External cutaneous, muscles of arm, skin forearm (external).
Internal cutaneous, skin arm, and forearm (internal).
Median, muscles forearm (anterior), palm of hand and fingers (except as by ulnar).
Ulnar, muscles of forearm (ulnar side), skin of wrist and fingers (little and ulnar side of ring).
Musculo-spiral, muscles and skin arm (chiefly posterior); divides into:—
RADIAL, skin dorsal side of wrist and fingers (with ulnar).
POSTERIOR INTEROSSEOUS, muscles forearm (posterior).
CIRCUMFLEX, shoulder joint.

DORSAL NERVES (form no plexuses; twelve in number).
Intercostal muscles, breasts, muscles and skin of lower part of thorax (anterior surface), and upper part abdomen.

LUMBAR PLEXUS (12th dorsal, 1st, 2d, 3d, 4th lumbar).
Muscles and skin lower part abdomen, external genitals, hip and knee joints, muscles of thigh (anterior surface), skin leg and foot (internal surface).

Anterior Crural, muscles anterior surface thigh, skin inner surface leg and foot (by Long Saphenous).

SACRAL PLEXUS (5th lumbar, 1st, 2d, 3d, and 4th sacral).
Shin and muscles of hip (Gluteal region), external genitals and all of lower extremity, except as by lumbar plexus.

Great Sciatic, muscles posterior part thigh; divides into:—
INTERNAL POPLITEAL, muscles of leg, tibial side (by Posterior Tibial), plantar surface foot (by External and Internal Plantar), ankle joint.
EXTERNAL POPLITEAL, knee joint, muscles of leg, anterior surface (by Anterior Tibial), fibular side leg, skin of dorsum of foot and toes (by Anterior Tibial and Musculo-cutaneous).

Spinal nerves take their names from intervertebral foramen, at which enter the spinal canal. Within canal course varies: in cervi-

cal and dorsal regions reach cord near level at which they enter canal, but in lumbar and sacral regions (since cord ends at 1st lumbar vertebra) their course is nearly perpendicular, and they form the "cauda equinæ."

SECTION XXVI.—SPINAL CORD.

SPINAL CORD occupies vertebral canal from foramen magnum to lower edge 1st lumbar vertebra.

Length, 18 inches; size varies in different parts.

Consists of central gray mass surrounded by white fibres (chiefly longitudinal).

Partially divided in halves by anterior and posterior fissures.

Gray matter arranged in two crescents, joined by their convex surfaces, point of union being central canal.

Anterior horns, or cornua, short, broad, do not reach surface of cord. From them issue efferent nerve roots.

Posterior horns, or cornua, long and thin, and reach surface. Into them enter posterior nerve roots.

Consists of nerve cells and fibres (mostly gray), forming dense network bound together by connective tissue (neuroglia).

Cells chiefly in groups in special parts.

Those of anterior cornua large, multipolar.

Those of posterior small, scanty, few poles.

Fibres that connect lateral valves of gray matter, (anterior and posterior gray commissures).

White matter consists of fibres, mostly longitudinal; — arranged in masses called columns (anterior, lateral, posterior).

Columns of cord form connections between: —

Spinal nerves and brain;

Gray matter of cord and brain;

Different levels of cord.

Afferent nerve fibres all enter posterior cornua.

Course complicated, but fibres either connect themselves with cells of posterior cornua or soon become perpendicular, and ascend to the brain in posterior or lateral columns.

A large portion cross in posterior gray commissure before entering columns.

Efferent nerve fibres originate either in cells of anterior

cornua or are made of fibres descending from brain in anterior or lateral columns.

A few white fibres cross from one side to other at bottom of anterior fissure, forming "white commissure."

Cells of anterior and posterior cornua (same side) connected by network of gray fibres.

Spinal nerves therefore enter into two distinct nervous circuits.

1st, From posterior nerve roots through cord from posterior nerve cells to anterior nerve cells, emerging from anterior cornua in anterior nerve roots.

2d, From posterior nerve roots ascending to nerve centres in brain, from which impulses descend the cord to emerge in anterior nerve roots.

SECTION XXVII.—BRAIN.

BRAIN consists of cerebrum, cerebellum, pons Varolii, medulla oblongata.

Cerebrum, upper and larger portion; superior surface convex, fills vertex; inferior surface divided into lobes.

Anterior and middle lobes fill anterior and middle fossæ; posterior lobe rests on cerebellum.

Divided into two hemispheres above by longitudinal fissure, prolonged anteriorly and posteriorly, as anterior and posterior fissures.

Hemispheres united near base by *corpus callosum*.

Connected with pons Varolii by two masses of white fibres, the *crura cerebri*.

Cerebellum (hind brain) lies below posterior cerebral lobe, and occupies part of posterior cerebral fossa.

Connected by bands of fibres called "peduncles" with each of other part of brain.

Pons Varolii, "the bridge" which connects different parts of brain together.

Flattened, pyramidal-shaped mass, larger extremity upwards; lies on basilar process.

Connected above with cerebrum by crura cerebri.

Connected laterally with cerebellum by cerebellar peduncles (middle portion).

Below continuous with medulla.

Medulla oblongata, enlarged upper end of spinal cord; lies on basilar process.

Place where fibres descending from brain to cord cross each other and descend on opposite side.

Membranes of brain, often called "meninges."

Dura mater, fibrous membrane; covers surface, and dips into fissures. At base continuous with periosteum anteriorly; forms *tentorium cerebelli* between cerebrum and cerebellum.

Arachnoid, very delicate membrane; covers surface.

Pia mater, delicate lace-like membrane; covers surface, and dips down between convolutions; contains blood vessels.

BASE OF BRAIN includes inferior surface of anterior and middle lobes of cerebrum, crura cerebri, pons Varolii, medulla oblongata, and cerebellum.

Anterior and middle lobes separated by fissure of Sylvius.

Olfactory bulb seen on each side median line on anterior lobe.

Middle lobes separated in median line by diverging crura cerebri, over which wind the optic tracts which form on median line the optic commissure.

Posteriorly, inferior surface of pons and medulla occupy middle portion, the cerebellum filling lateral regions.

Superficial origin of all cranial nerves, all except first two coming from pons or medulla: —

CRANIAL NERVES AND THEIR DISTRIBUTION.

1st, Olfactory.		Mucous membrane of nose.	Special sense (smell).
2d, Optic.		Retina of eye.	Special sense (sight).
3d, 4th, 6th,		Muscles of eye.	Motion.
5th, Trigemini	1st Division.	Orbit, forehead.	Sensation.
	2d "	Face between orbit and upper lip, upper teeth.	
	3d "	Face between upper lip and chin, lower teeth.	
	3d "	Tongue.	Special sense (taste).
	3d "	Muscles of mastication.	Motion.
7th, Facial.		Muscles of face.	Motion.
8th, Auditory.		Internal ear.	Special sense.
9th, Glosso-pharyngeal.		Tongue, pharynx, tonsils.	Sensation.
10th, Pneumogastric.		Larynx, pharynx, œsophagus, heart, lungs, stomach.	Motion and sensation.
11th, Spinal Accessory.		Trapezius.	Motion.
12th, Hypoglossal.		Muscles of tongue.	Motion.

Cerebrum, structure of: —

Surface, a layer of gray matter arranged in folds or convolutions. Into these convolutions radiate masses of white

fibres which make connection between cerebral cortex and parts within substance of brain.

Near base several great ganglionic masses; namely, Corpora Striata, Thalami Optici, Corpora Quadrigemini.

These occupy partly space between commissure above (corpus callosum) and radiating fibres to convolutions below.

Spaces known as ventricles.

Fibres entering or leaving cerebral hemispheres pass through crura cerebri, afferent fibres occupying posterior part, efferent fibres anterior part.

Cerebral localization: areas for localization of different muscular movements and conscious sensations have been fixed upon to some extent, and it is probable that eventually each convolution will prove to have some special work of which it is the centre.

Best known regions are the motor areas surrounding fissure of Rolando.

Motor area for leg movements.

Motor area for arm movements.

Motor area for face movements.

Centre for speech, fissure of Sylvius, left side.

Centre for sight, posterior lobe.

Centre for smell, middle lobe, anterior extremity.

Centre for hearing, temporo-sphenoidal lobe.

Cerebellum gray externally, white internally; gray and white foldings form arbor vitæ.

Pons and medulla chiefly white fibres on their way to or from other parts of nervous system.

Scattered through white matter many gray masses, called "nuclei," from which all of cranial nerves except optic and olfactory take origin.

SYMPATHETIC NERVOUS SYSTEM controls parts of body that act independent of will.

Great Sympathetic nerve is a double chain of ganglia extending from within cranium to front of coccyx, where it terminates in one small ganglion.

Lies on each side vertebral column, and its ganglia take name of region in which they lie; namely, cephalic, cervical, dorsal, lumbar, sacral.

Each ganglion connected by nerve fibres with one above and below, and also with cerebro-spinal system.

Nerves of sympathetic proper all gray.

Nerves forming connection with cerebro-spinal system white.
From this chain given of plexuses distributed to blood vessels and internal organs, chief plexuses: —
Cardiac and Pulmonary to heart and lungs.
Solar (surrounds cœliac axis, receives splanchnic nerves from lower dorsal region), distributed to all abdominal organs, descending to each by its accompanying artery; contains "semilunar ganglia."
Hypogastric plexus supplies all pelvic organs.

PHYSIOLOGY OF NERVE ACTION: —

1. **Conscious sensation and voluntary motion.**
Sensations received by afferent nerve fibres transmitted to cerebral cortex, the nerve power there developed descending by efferent fibres to voluntary muscles.
Examples in ordinary sensations with their resulting muscular movements.
2. **Reflex action**, the transmission of an efferent impulse to a lower nerve centre, where it gives rise to an efferent impulse without any influence of will.
Seen best in lower animals in spinal cord.
Reflex centres for vomiting, swallowing, vaso-motor action in medulla.
Sympathetic nerve centres.
3. **Automatic action** differs from reflex action chiefly by the fact that an automatic centre may be directly stimulated, the stimulus not being necessarily an afferent impulse.
Example: respiratory centre stimulated by carbonic acid in blood.
4. **Psychical and mental action.**
Power of purely intellectual acts supposed by some to originate in cells of cerebral cortex, by others to be stimulated by impressions received from without by afferent nerves.

Function of Cerebellum; so far as known, believed to be co-ordinating centre through whose means complicated acts are co-ordinated.

SECTION XXVIII.—EXCRETIONS AND PROCESS OF EXCRETION.

EXCRETION, the process by which waste and injurious products are removed from the body.
All parts of body continually wearing out. If worn-out products

are not removed, they not only prevent proper nutrition, but act as poisons in the system.

Principal avenues by which worn-out materials leave body: —

1. Lungs, excretion,— CO_2 and gaseous impurities.
2. Skin, excretion,— perspiration.
3. Kidneys, excretion,— urine.
4. Liver, excretion,— portion of bile.
5. Intestines, excretion,— fæces.

Of these excretory organs, the kidneys alone have excretion for their sole work.

Lungs: excretory work has been described in respiration.

Skin covers body externally; two layers, epidermis and derma, or true skin; protects delicate tissues beneath; retains warmth; secretes and excretes perspiration.

EPIDERMIS, upper layer, consists of flat scales which protect parts beneath.

This layer has no nerves or blood vessels; is constantly being thrown off as dead skin.

Nails, hair, claws, hoofs, etc., belong to epidermis.

Thickness inversely as sensitiveness of part; thickest wherever greatest pressure occurs, as soles of feet; thinnest, ball of fingers, lips, breasts, etc.

DERMA, below epidermis, very sensitive.

Close, felt-like, fibrous structure above, loose meshes below. Contains fat, sweat glands, hair follicles, sebaceous follicles, nerves, and blood vessels.

Surface usually ridged, the ridges forming the papillæ into which blood vessels and nerves enter.

Sweat glands, coiled up tubes which open on surface between papillæ by small ducts surrounded by capillaries, from which they take material to form perspiration. Have around the mouths of ducts a few involuntary muscular fibres, by which they are opened or closed.

Hair follicles, infolding of epidermis to form beds for the hair.

Sebaceous glands, small, flask-like glands, which secrete oily fluid which keeps skin and hair moist and soft. Usually open into a hair follicle.

Perspiration (combination of secretions of sweat and sebaceous glands) is a fluid consisting of water, salts, some organic matters: the latter are poisonous, if retained in system. Important regulator of bodily temperature.

Normal body temperature in all climates and conditions, 98.5.

Every process in body accompanied by production of heat.

When from internal or external cause bodily temperature tends to rise, mouths of sweat glands relax, and sweat is poured out, evaporation of which rapidly cools body.

When external air is cold, these openings close, and retain the heat for keeping body warm.

Condition of skin very important to bodily health.

If epidermis is not constantly removed, mouths of sweat glands are blocked up, and excretion is hindered.

If cutaneous circulation is not active, sweat glands cannot obtain material to excrete.

Constant washing and friction of skin necessary to keep it healthy.

Baths,— warm, hot, and cold.

Conditions regulate hygiene of bathing.

Kidneys, two glands whose sole office is to manufacture urine.

Materials of urine taken from blood supplied to kidney by renal arteries.

Consist of outer cortical portion, and inner medullary portion.

Cortical portion consists of larger numbers of small tubes, or "tubuli uriniferi," most of which are convoluted.

Each tube begins in a bulb-like enlargement, the Malpighian body.

Surrounding the tubes are vast numbers of capillary blood vessels, from which the tubes obtain material for urine.

Medullary portion consists of pyramidal-shaped masses of straight tubes, which open by their apices into the pelvis of kidney. Between the tubes run many capillary blood vessels.

Urine, secreted in twisted tubes, is poured by straight tubes into pelvis.

Pelvis of kidney, large cavity on its concave border, which opens into ureter, by which urine is removed from kidney to bladder.

Secretion of urine is constant, so bladder is the reservoir where urine is retained till it can be removed.

Urine, clear, yellow, acid fluid. Specific gravity, 1.015–1.020.

Quantity in twenty-four hours averages three pints.

Principal constituents, water, salts, urea, uric acid, coloring matter.

Urea and *uric acid*, products of worn-out nitrogenous tissues of body.

Urea deadly poison, which, if allowed to accumulate in system, causes headache, stupor, convulsions, and very soon death.

Amount varies with temperature, amount and nature of food and drink taken, action of skin, mental conditions, etc.

Skin and kidneys have a somewhat reciprocal action. Skin can excrete water and salts, and in some cases a small amount of urea.

Pure water in sufficient quantities needed to keep kidneys active.

Liver, largest gland in body; secretes bile.

Upper surface, smooth and convex.

Lower surface, divided into lobes, between which blood vessels and bile duct enter substance of liver.

Gall bladder lies in under surface.

Right extremity rounded and thick; left sharp and thin.

Receives venous blood from stomach, intestines, spleen, and pancreas by the *Vena Porta*.

Framework of connective tissue (capsule of Glisson) ramifies through every part, dividing it into lobules.

Branches of vena porta, hepatic artery, and hepatic duct, follow the capsule of Glisson to every lobule.

Vena porta by its branches (*interlobular*) surrounds each lobule.

Interlobular veins send centripetal capillaries to centre of lobule.

Lobular capillaries unite in centre to form *intralobular veins*.

Intralobular veins become *sublobular* as they leave lobule.

Sublobular veins unite to form *hepatic veins*.

Hepatic artery serves chiefly to nourish substance of liver.

Hepatic or bile duct collects bile.

Bile formed within the lobules from blood of capillaries, and carried by "bile capillaries" to hepatic duct, a branch of which surrounds each lobule.

On leaving liver unites with pancreatic duct to form "Ductus Communis," and enters duodenum.

Cystic duct leads from hepatic duct to gall bladder, which is an overflow place for bile.

Bile, clear, golden-brown fluid, alkaline reaction, contains salts useful in digestion, coloring matter, and excretory substances, chief of which is *cholesterine*.

Cholesterine, if retained, causes symptoms of narcotic poisoning, not so severe as urea.

Liver also has important office in changing sugar formed in digestion into glycogen. Process not well understood.

Fæces, chiefly waste-food products, mixed with intestinal secretions and bile, excreted by large intestines.

If not regularly excreted, these products ferment and putrefy, portions of them are gradually reabsorbed into blood, causing a form of slow poisoning.

Chronic constipation causes headache, slow mental processes, general sluggishness and torpor, which affects general health more or less.

General directions in regard to regulating bowels.

(To avoid making this book unduly long, the portions of the lectures relating especially to hygiene are only indicated, the full synopsis being omitted.)